

U.S. PATENT APPLICATION

for

FLEXIBLE TRUCK BED TIE-DOWN SYSTEM

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FLEXIBLE TRUCK BED TIE-DOWN SYSTEM

FIELD OF THE INVENTION

[0001] The Applicants hereby claim the benefit of the U.S. provisional application 60/242724 entitled "Flexible Truck Bed Tie Down System and Gate Extender," filed October 25, 2000. The entire contents of this provisional application are incorporated herein by reference. The present invention relates generally to the field of trucks. More specifically, the present invention relates to a flexible tie-down system for trucks.

BACKGROUND OF THE INVENTION

[0002] The explosion in the popularity of pick-up trucks and/or sport utility trucks (SUTs) has fueled a proliferation of new body configurations. Trucks are offered as standard cabs, king cabs, crew cabs, SPORT TRACS, and the like. Likewise, truck interiors have been adapted to meet the needs for more comfort, more passenger capacity, and the like. One area of the pick-up truck that has yet to undergo a similar evolution is the cargo bed itself.

[0003] It is ironic that the most utilitarian element of what is essentially a utilitarian vehicle is, in practical terms, not especially useful. As currently conceived, the standard full-sized pick-up bed is little more than a large empty volume with a few tie-down points scattered along the perimeter of its interior walls or along a bed rail. There is an enormous opportunity to improve the utility and ease of use of a truck bed.

[0004] Some trucks are used primarily for work and others primarily for recreation. Many trucks do double-duty supporting both of these spheres of activity. One of the most glaring deficiencies of current bed design is that they are not readily adaptable to the wide variety of applications required by the end user. A truck bed should be able to support and

accommodate the very different requirements that are associated with a diverse range of activities.

[0005] Generally speaking, bed usage may be grouped into three broad categories: hauling, securing, and separating items in the payload. Most truck users need to perform each of these tasks with some frequency.

Yet the demands placed on the bed for hauling are significantly different from those needed to secure or separate items in and around the bed.

[0006] When hauling yard waste, plywood, recreational gear, and other items, the ideal condition is to maximize the interior volume of the bed and to maintain an easily accessible loading surface. When securing individual objects in the bed, such as dirt bikes, ATVs, air tanks, furniture, and other items, the ideal condition is to have multiple sturdy tie-down points in close proximity to the object being secured. When hauling and securing combinations of items — heavy objects and fragile equipment, for example — it becomes necessary to separate these items from one another.

[0007] This situation has led to a brisk business in after-market systems created by after-market manufacturers. However, while many of these systems are at least partially effective, they are not necessarily designed to interface with the truck in an optimum manner from a functional, structural, and aesthetic standpoint.

SUMMARY OF THE INVENTION

[0008] An object of the invention is to provide a truly flexible cargo bed tie-down system that allows the user to easily change, adjust, customize, and adapt his or her vehicle to specific needs at any given moment, and that interfaces with the rest of the truck in an optimum manner from a functional, structural, and aesthetic standpoint.

[0009] An important feature of the invention is that, in the invention, tie-down track(s) are provided that are integral with the body of the truck

such that the exterior contour of the track(s) do not extend appreciably beyond the contour of the adjacent portions of the body. This permits the track(s) to blend in with the body of the truck, which improves functionality because the track(s) do not obstruct the placement of items on the truck. This also permits the portions of the body of the truck that support the tracks(s) to be specifically designed to take large loads, which thus allows the track(s) to support, separate and/or secure large loads. This is in contrast to currently available after-market products which sit on top of the body of the truck. Such after-market products and existing trucks are not necessarily designed to interface in an optimum manner, from a functional, structural and aesthetic standpoint.

BRIEF DESCRIPTION OF THE DRAWINGS

- [0010] The invention will be described in further detail below in conjunction with the following drawings:
- [0011] Figure 1 is an end view of a truck embodying the invention.
- [0012] Figure 2 is a sectional view of plane 2-2 of Figure 1.
- [0013] Figure 3 is a sectional view of plane 3-3 of Figure 1.
- [0014] Figure 4 is a sectional view of plain 4-4 of Figure 1 (with a tie-down fitting installed).
- [0015] Figure 5 illustrates an example of a tie-down fitting.
- [0016] Figure 6 illustrates another example of a tie-down fitting.
- [0017] Figure 7 illustrates an example of a tire cradle.
- [0018] Figure 8 illustrates an example of a tank fitting.
- [0019] Figure 9 illustrates an example of a cargo net arrangement.
- [0020] Figure 10 illustrates an example of a cargo divider.
- [0021] Figure 11 illustrates an example of a foldable storage box in a stored position.
- [0022] Figure 12 illustrates the foldable storage box being placed in the storage position.

[0023] Figure 13 illustrates the foldable storage box in the storage position.

[0024] Figures 14 through 17 illustrate an example of a tailgate extender, having a track, in four different positions.

[0025] Figure 18 illustrates an example of an arrangement of crossbar members.

[0026] Figure 19 illustrates an example of a pulley arrangement supported by the crossbar members.

[0027] Figure 20 illustrates one possible configuration of a track and fittings on a crossbar member.

[0028] Figure 21 illustrates a sectional view of plane 21-21 of Figure 20.

[0029] Figure 22 illustrates an example of a storage box for storing tie-down fittings and/or other items.

[0030] Figure 23 is a sectional view of the storage box of Figure 22.

[0031] Figure 24 is an example of another arrangement of tracks, according to the invention.

[0032] Figure 25 is an example of another arrangement of a track, according to the invention.

[0033] Figure 26 is an example of another arrangement of tracks, according to the invention.

[0034] Figures 27 through 31 illustrate a type of fitting that may be used according to the invention.

[0035] Figures 32 through 34 illustrate another type of fitting that may be used according to the invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0036] Figure 1 illustrates an end view of a truck 100 configured in accordance with one embodiment of the invention.

[0037] As shown in Figure 1, the truck 100 has a cargo bed, or area, 110 behind a cab (or passenger compartment) 120. There are two sidewalls 122, 124 on the sides of bed 110 and front wall 125. In this particular configuration, the truck 100 also includes a tailgate 130. Tracks 141 and 142 are located in bed 110. The left sidewall 122 has a track 143 which opens inward and another track 144 which opens upward. Similarly, sidewall 124 has an inward facing track 145 and an upward facing track 146. A rearward facing track 147 is located on front wall 125 behind cab 120, and the free end of tailgate 130 includes a track 148.

[0038] Figure 2 is a sectional view of plane 2-2 of Figure 1. Figure 2 illustrates track 141 recessed in bed 110. The track 141 is in the shape of a channel and has two inward turning lips 141A and 141B. The track 141 is provided with a slot opening S. The design of track 142 (with respect to bed 110) is similar to the design of track 141.

[0039] Figure 3 is a sectional view of plane 3-3 of Figure 1. As shown in Figure 3, track 148 is located on the free end of tailgate 130. Track 148 has inward turning lips 148A and 148B and a slot opening S.

[0040] Figure 4 is a sectional view of plane 4-4 of Figure 1, with a tie-down fitting installed. As illustrated, track 145 faces inward and track 146 faces upward. The design of tracks 145 and 146 is similar to the design of tracks 141 and 148, as discussed above. Similarly, tracks 143 and 144 are similar to tracks 145 and 146.

at [0041] ~~An important feature of the invention is that the tracks are outside of the passenger compartment (in the Figure 1 embodiment the tracks are behind the passenger compartment). This allows the storage of larger, heavier loads. Another important feature of the invention is that the tracks 141 to 148 are integral with the body of truck 100 such that the exterior contours of the tracks do not extend appreciably beyond the contour of adjacent portions of the body.~~

[0042] For example, the exterior contour of track 141 is flush with cargo bed 110. In Figure 3, the upper horizontal surface of track 148 is flush with the uppermost portion 132 of tailgate 130 and the surface 148C of track 148 is flush with the surface 134 of tailgate 130. Similarly, as shown in Figure 4, the exterior contours of tracks 145 and 146 do not extend appreciably beyond the contour of adjacent portions of the body.

[0043] This design permits the tracks to blend in with the body of the truck, which improves functionality because the tracks do not obstruct placement of items into or on the truck. Also, in the invention, the portions of the body of the truck that support the tracks are specifically designed to accommodate the tracks and to take large loads, which thus allows the tracks to support or secure large loads. As discussed above, this is in contrast to currently available after-market products which sit on top of the body of the truck. Such after-market products and existing trucks may not necessarily be designed to accommodate each other in an optimum manner, from a structural viewpoint.

[0044] The contour of the adjacent portions of the body of the truck can be formed by, for example, structural steel, aluminum and other material that forms part of the structural part of the body, sheet metal, sheet aluminum or other material, and/or plastic (either separate or with a track encapsulated). The track slots can be pointed in any direction, for example, upward, downward, outboard, inboard, rearward, forward, or at an angle. Also, when the tracks are not in use, the tracks can be covered with a protective strip of, for example, rubber or plastic, which fits into the slot opening.

[0045] In this particular embodiment of the invention, the geometry of the tracks is similar to the geometry of channels manufactured for industrial framing applications (for example for supporting pipes and electrical lines). This allows a user to employ a wide variety of

commercially available fittings to customize and adapt the tie-down arrangement to the particular task at hand.

[0046] Figures 4 and 5 illustrate an example of a tie-down fitting 210. Fitting 210 may be used with rope, straps, and the like to secure items in and/or to the bed. This fitting 210 has three separate parts, a nut 212 available from (for example) the manufacturers listed below, a male threaded commercially available eye 214, and a washer 216. The nut has two grooves 212A and 212B that are intended to mate with the in-turned lips of the track (such as lips 145A and 145B of track 145). In this embodiment, washer 216 has a metal portion 216A and an elastic portion 216B. This fitting can be moved anywhere along a track and then fixed in a desired location. The fitting can also be released from the track, for example, by twisting or unscrewing the fitting and then removing the fitting in a direction approximately perpendicular to the track. Providing fittings that can be inserted anywhere along the track and that are movable within the track allows the user to customize and adapt the truck to the task at hand by providing the appropriate number and spacing of fittings required for the task at hand. Also, because the fittings are releasable, they can be removed when not needed, so that they do not become an obstruction.

[0047] To use the assembly, the nut 212 is placed into the channel (or track), the washer 216 is placed on a threaded part of the eye 214, and then the nut 212 is turned 90 degrees such that the grooves 212A, 212B in the nut mate with the in-turned lips 145A and 145B of the channel. Then, the eye is screwed into the nut until tight. This squeezes the track between the nut and the washer/eye assembly. The pressure locks the entire assembly to the track. The fitting is removed by loosening the nut/eye assembly, and turning the nut 90 degrees.

[0048] Figure 6 illustrates another example of a tie-down fitting 310. This fitting 310 can be used for securing a wide variety of items to a

track. As shown in Figure 6, fitting 310 includes a commercially available nut 312, a knob portion 314, a plastic or steel washer 315, and a washer 316. A contact portion 314A of knob 314 is designed to hold an object between contact portion 314A (and washer 315) and a track. The washer 316 is bonded to the nut 312 and rests on top of the track to keep the nut from falling into the track. An example of use of such a fitting will be described in further detail below in conjunction with Figures 10, 20 and 21.

[0049] Figure 7 illustrates an example of a specialized fitting 400 having a tire cradle 410 for use with the track system described above. This fitting 400 can be positioned and then secured, for example, to track 147 on front wall 125 behind the cab using fittings 420 and 430. Fittings 420 and 430 are similar to fitting 210, described above. Two straps 411 and 413 are used to secure a tire within the cradle 410. This tire cradle can be used with the other fittings described in this patent specification to provide numerous tie-down points to stabilize, for example, a mountain bike or motorcycle, within the cargo bed.

[0050] It will be appreciated that the fittings described in this patent specification can be used in conjunction with, for example, ropes, straps, rubber tie-downs, and the like, to secure objects to tie-down points throughout the cargo bed.

[0051] Figure 8 illustrates an example of a tank fitting 510 for use, for example, with the side tracks described above. Fitting 510 includes two commercially available bands 512 and 514 which are approximately in the shape of a quarter circle. The bands are joined at one end by a tightening assembly, such as a threaded knob 516. The other ends of the bands are shaped to lie within one of the tracks (for example, track 145, as shown in Figure 8). Such fittings allow adjustable and secure placement of, for example, scuba tanks, and the like, near the bed perimeter.

[0052] Figure 9 illustrates an example of a cargo net arrangement 600. Arrangement 600 includes a cargo net 610 which is secured to tracks 141, 142, and 148 using fittings 622, 624, 626, and 628. Fittings 622, 624, 626, and 628 are similar to fitting 210, shown in Figure 5.

[0053] The tracks at the side of the bed and/or the tracks at the bottom of the bed, can also be used to secure a cargo divider, as shown in Figure 10. Figure 10 illustrates a cargo divider 710 secured to tracks 141, 142, 144, and 146 using fittings 722, 724, 726, and 728. Fittings 722, 724, 726, and 728 are similar to fitting 310, shown in Figure 6.

[0054] Figures 11 to 13 depict a folding/stowable box arrangement 800 which is provided by the invention. Figure 11 illustrates an example of the box in the storage position. When not in use, a lid 810 of the box and a rear side 820 of the box are folded together and are stored flat against the front wall 125 of the cargo bed to maximize bed space, as shown in Figure 11 (in Figure 11, the lid 810 is hidden behind the side 820). When the user desires to place the box in the storage position, both the lid 810 and the rear side 820 are moved rearward using fittings 822 and 826 to guide the side 820 and maintain the side 820 approximately perpendicular to the cargo bed. Then, knobs 824 and 828 are tightened to secure fittings 822 and 826 to tracks 145 and 143. Then, lid 810, which is stored in slots 821 of side 820 (lid 810 is not shown in Figure 12 in order to show slot 821 clearly), is pivoted, for example by a hinge, to cover the interior of the box, as shown in Figure 13.

[0055] Figures 14 through 17 illustrate an example of a tailgate extender 900, having a crossbar member 948, in four different positions. As shown in these figures, the tailgate 130 is positionable such that the primary plane of the tailgate 130 is either vertical (Figure 14) or horizontal (Figures 15 to 17). Crossbar member 948 runs in a direction perpendicular to the longitudinal direction of the truck. A first member

952 and a second member 954 are connected to the crossbar member 948. The first member 952, the second member 954, and the crossbar member 948 lie in the same plane. A connection assembly (to be described below) connects the crossbar member 948 to the tailgate 130 via at least the first and second members 952 and 954 such that:

[0056] (1) the first member 952, the second member 954, and the crossbar member 948 lie in the primary plane of the tailgate 130 to act as an upright for loads when the tailgate 130 is vertical (as shown in Figure 14);

[0057] (2) the first member 952, the second member 954, and the crossbar member 948 lie in the primary plane of the tailgate 130 to act as an extension of the tailgate 130 for longer loads when the tailgate 130 is horizontal (as shown in Figure 15);

[0058] (3) the first member 952, the second member 954, and the crossbar member 948 lie in a plane perpendicular to the primary plane of the tailgate 130 to act as an upright (or rear support) when the tailgate is horizontal (as shown in Figure 16); or

[0059] (4) the first member 952, the second member 954, and the crossbar member 948 lie in a plane perpendicular to the primary plane of the tailgate 130 to act as a step when the tailgate 130 is horizontal (as shown in Figure 17). (Also, the tailgate extender can be positioned as shown in Figure 17, except with the tailgate closed, to provide another configuration, for example, for storing long objects.)

[0060] The first and second members 952 and 954 can be stored within the tailgate 130 by pushing them into the tailgate (in which case the crossbar member 948 simply acts as a track on the free end of the tailgate similar to track 148 in Figure 1). The first and second members 952 and 954 are secured to the tailgate 130 in one of the three relative positions by: (1) sliding the first and second members 952 and 954 into one pair of holes 962 and 964 which are parallel to the primary plane of

the tailgate and securing the members by pins 932 and 934; or (2) sliding the first and second members 952 and 954 into one pair of holes 961 and 963 which are perpendicular to the primary plane of the tailgate 130 and securing the members by pins 932 and 934. Pins 932 and 934 go through holes in tailgate 130 and members 952 and 954.

[0061] Figures 18 and 19 illustrate an example of an arrangement 1000 of crossbar members 1100 and 1200 that can be used to support, for example, ladders, plastic pipe, a large sea kayak, and other long objects. These crossbar members allow the cargo bed 1010 to be free for other gear. In addition, the longitudinal spacing of the crossbar members 1100 and 1200 can be adjusted to secure tall objects (such as appliances) between the crossbar members. (One way of securing such crossbar members to the tracks will be described below in connection with Figures 20 and 21.)

[0062] The crossbar members 1100 and 1200 can support, for example, a beam 1310 that can be cantilevered near the rear end of the truck to support a pulley system 1320. Figure 19 illustrates an example of pulley system 1320 being employed to easily load a heavy, awkwardly-sized object (wheel W) into the cargo bed 1010. In one variation, upward facing tracks 144 and 146 may be eliminated and crossbar members 1100 and 1200 are secured to inward facing tracks 143 and 145.

[0063] Figure 20 illustrates one possible configuration of a track 1410 and fittings 1420, 1430, and 1440 on a crossbar member 1400. Fittings 1420, 1430, and 1440 are commercially available from various industrial framing manufacturers (listed below). As described above, one of the advantages of the invention is that a vehicle owner may use a wide variety of readily available fittings, in conjunction with the track system, to customize his or her truck and adapt the truck to the owner's particular requirements at hand. It will be appreciated that other types of fittings, which include additional tracks, can be provided.

[0064] Figure 21 illustrates a sectional view of plane 21-21 of Figure 20. As shown in Figure 21, crossbar member 1400 is secured to track 144 by securing a horizontal portion 1450 of crossbar member 1400 to the track using a knob fitting 1460 and a nut 1470. A suitable design for such a fitting is illustrated in Figure 6.

[0065] Figures 22 and 23 illustrate an example of a storage box 1500 in an outer side panel of a truck for storing fittings and/or other items. The box 1500 is supported by a slide 1510.

[0066] Figure 24 is an example of another arrangement 1600 of tracks, according to the invention. As illustrated in Figure 24, arrangement 1600 includes tracks 1610, 1620, 1640, and 1650 mounted to the inner sidewall of a cargo bed 1680 such that the exterior contours of these tracks do not extend appreciably beyond the contour of the adjacent portions of the body. Similarly, track 1630 is mounted to the front wall of cargo bed 1680 such that the exterior contours of the track do not extend appreciably beyond the contour of the adjacent portions of the body.

[0067] Figure 24 also illustrates tracks 1660 and 1670 which project approximately one inch above cargo bed 1680. Thus, tracks 1660 and 1670 do extend appreciably beyond the contour of adjacent portions of the body. Figure 24 illustrates that tracks according to the invention (tracks 1610, 1620, 1630, 1640, and 1650) may be mounted on the same vehicle which also has tracks (1660 and 1670) which do extend appreciably beyond the contour of the adjacent portions of the body.

[0068] Figure 25 is an example of another arrangement 1700 of a track 1710, according to the invention, that does not extend appreciably beyond the contour of adjacent portions 1720 of the body.

[0069] Figure 26 is another example of another arrangement of tracks 1800, according to the invention. As shown in Figure 26, the arrangement includes a number of body panels, 1810, 1820, 1830,

1840, and 1850. The body panels are joined, for example, by fasteners 1862, 1864, and 1866. Tracks 1872 and 1874 are mounted to the body panels by, for example, welds 1871, 1873, 1875, and 1877. The tracks can be connected to the body by other means, such as bolts. As shown in Figure 26, the tracks 1872 and 1874 are mounted to the panels such that the exterior contours of tracks 1872 and 1874 do not extend appreciably beyond the adjacent portions of the body. In the most preferred embodiment, the exterior contours of the tracks are substantially flush with the adjacent portions of the body. However, the exterior contours of the track can extend up to one-eighth of an inch beyond the adjacent portions of the body, one-quarter of an inch beyond the contour of the adjacent portions of the body, or up to one-half of an inch beyond the contour of the adjacent portions of the body.

[0070] Figures 27 to 31 illustrate another type of fitting 1900 that may be used. If the fittings described above in connection with Figures 5 and 6 are not tightened enough or if the eye (or knob) is turned, the assembly can loosen and may fall out of the track. On the other hand, if the fitting is tightened too tightly, especially in the case of an aluminum track, there could be damage or premature wear of the track.

[0071] The Figure 27-31 embodiment provides a more positive engagement with the track that does not rely as much on the user having the correct "feel" in tightening the thread/nut assembly. In this embodiment, the tie-down fitting does not clamp onto the track, but instead stays in place by a combination of a pin and a lock bar. As will be described below, this embodiment of the invention requires holes in the back side of the track(s).

[0072] As shown in the Figures, there are four major pieces to this design. A center shaft 1910 is provided with an eye 1920 (or other type of fitting/connection) on one end, a square shank 1930 in the middle, and a pin 1940 on the other end. Eye 1920, shank 1930, and pin 1940 are

formed together as one piece. A rectangular lock bar 1950 is provided with a hole the same diameter as the pin end 1940 of the center shaft 1910. A spring locking ring 1960 has a square hole to match the shank 1930 of the center shaft and includes a recessed area which houses an internal spring 1968, notches for fingers, and a boss 1962 to engage the track opening. A set screw 1952, or pin, secures the lock bar 1950 to the center shaft. In this particular configuration, a link 1922 is attached to the eye 1920 of the center shaft.

av ~~[0073] To assemble the unit, the spring 1968 is slid onto the center shaft 1910 stopping against a larger diameter near the eye end. The locking ring 1960 is then slid over the square shank 1930 of the center shaft 1910. Then, the lock bar 1950 is installed over the center shaft pin 1910, and is aligned so that the long side of the lock bar 1950 is perpendicular to a long side of the locking ring boss 1962 and is screwed (or pinned) in place by screw 1952.~~

[0074] To install the fitting 1900, the entire unit is positioned in a track 2020, opposite a track hole 2010, with the lock bar 1950 aligned with the track, as shown in Figure 29. The center shaft 1910 is pushed to overcome the spring pressure, allowing the lock bar 1950 to pass the sides of the track opening. Then, the entire unit is rotated until the boss 1962 on the locking ring 1960 aligns with the track opening and the spring forces the locking ring 1960 down against the track, as shown in Figure 30. This also causes the lock bar 1950 to be wedged in between the back of track 2020 and track lips 2022 and 2024 (this keeps the pin 1910 engaged in the hole 2010 and keeps the entire assembly from pulling out of the track). To remove, the thumb pushes down on the center shaft 1910 and fingers on either side of the locking ring 1960 lift the locking ring 1960 and boss 1962 away from the track opening, as shown in Figure 31. The entire unit is then rotated 90 degrees, allowing the locking bar 1950 to disengage from the track.

[0075] This embodiment thus provides an arrangement that is simple, easy to use, and provides very positive locking action. As long as the boss 1962 holds the lock bar 1950 from rotating, the only way to move or remove the tie-down fitting would require destruction or gross distortion of the track and/or tie-down fitting.

[0076] Figures 32 through 34 illustrate another type of fitting that may be used according to the invention. This type of fitting also requires tracks with holes. In this embodiment, the assembly 2100 includes a loop 2110 welded to a pin 2120 after the pin is inserted through a plastic (or metal) spring 2130 and spacer 2140, which in turn is mechanically bonded to a rectangular metal locking bar 2150. This arrangement allows the loop/pin assembly to spin freely with respect to spring 2130, spacer 2140, and locking bar 2150 at all times. A projection 2122 on the bottom of pin 2120 and a projection on the top of pin 2120 (not visible in the drawings) maintain spring 2130, spacer 2140, and bar 2150 on the pin (while still allowing relative rotation therebetween).

[0077] To use this fitting 2100, the fitting is positioned over the track 2220 above a track hole 2210, as shown in Figure 33. The pin 2120 is inserted into the hole 2210, with the rectangular locking bar 2150 positioned to drop into the track. The spring 2130 (and therefore the locking bar 1950) is then twisted 90 degrees clockwise until detents 2132 and 2134 on the underside of the spring drop into the track, as shown in Figure 34. The tension between spring 2130 and locking bar 2150 on the track 2220 maintain the assembly in this position.

[0078] To remove this tie-down, the spring 2130 (and the locking bar 2150) is rotated counter- clockwise.

[0079] Numerous other types of fittings may be used with the invention, for example, supports for plate glass racks, supports for ladders, and the like. Suitable off-the-shelf fittings are readily available for strut systems and are offered by, for example, Unistrut (Wayne,

Michigan); Midland-Ross Corp., Superstrut Division, (Oakland, California); and B-Line Systems, Inc. (Highland, Illinois).

[0080] The invention is not limited to the preferred embodiments described above. For example, a track could be mounted directly to the tailgate without the use of members 952 and 954. Variations and modifications of the invention will occur to those in the field, in light of the above teachings. The invention is therefore defined by reference to the following claims.

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